CR# 172101

LBSS

Trajectory Analysis of Transfers Between L4 and L5 and Low Lunar Orbit

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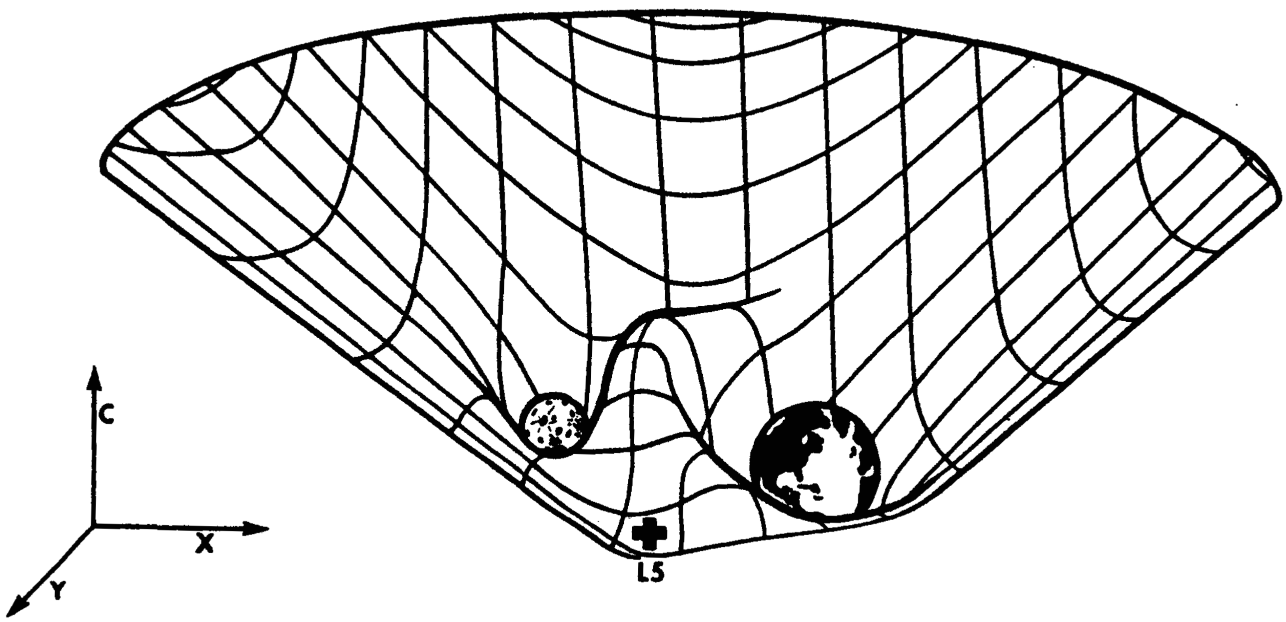

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October 30, 1988

EAGLE

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Prepared for the
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Eagle Engineering, Incorporated
Report Number: 88-216

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FOREWORD

This report discusses the flight characteristics and spacecraft performance during missions involving flight between the equilateral libration points and the Moon. The conclusions drawn will show that a minimum energy trajectory is the most efficient transfer technique for this type of flight.

Dr. J.W. Alred was the NASA technical monitor for the ASTS contract. Mr. A. Petro was the NASA task monitor for this activity. The overall Eagle project manager was Mr. W.R. Stump. Mr. C.C. Varner performed the analysis and wrote the report.

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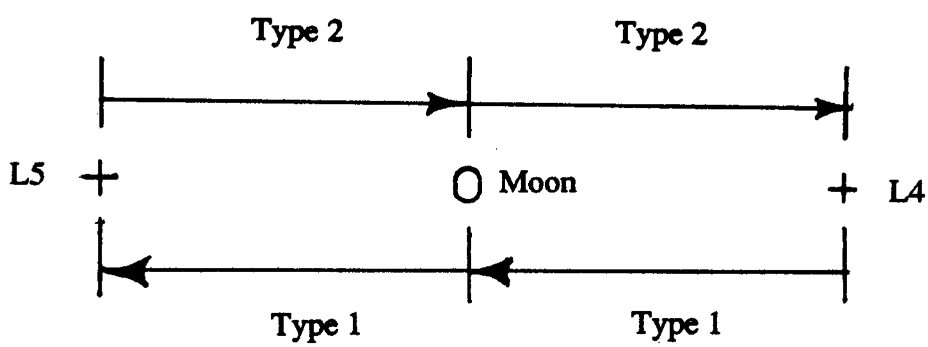
1.0 Executive Summary

Libration points 4 and 5 are, respectively, locations in space 60° behind and ahead of the Moon in its orbit. Theoretically, there is no tendency for an object to leave these locations relative to the Earth and Moon, and if displaced, the gravitational stability tends to return the object to the libration point. This report discusses the aspects of trajectory design and analysis for flights between these two libration points and the Moon. The conclusions are as follows.

A minimum energy trajectory provides the most economical method of travelling between the Moon and the libration point. Based on the work of Broucke, the transfer flight time is 395 hours (16.5 days) for flights from L4 to the Moon and from the Moon to L5 ("Type 1" flights). For flights from L5 to the Moon or from the Moon to L4 ("Type 2" flights), the flight time is 565 hours (23.5 days). The minimum total velocity change required by the spacecraft is 757 m/s for the "Type 1" flights and 737 m/s for "Type 2" flights. For "Type 1" flights a 677 m/s velocity change is required in a 100 km low lunar orbit, and a 80 m/s velocity change is necessary at the libration point. "Type 2" flights require 677 m/s in low lunar orbit and 60 m/s at the Libration Point.

Figure 1: Diagram of Type 1 and 2 Flights



For short flight times, Gauss' solution to Lambert's Problem is sufficiently accurate to predict the flight time and Delta V's. For flight times approaching the period of a lunar orbit, the errors in the flight time make it necessary to use other solution techniques such as those presented by Broucke in his analysis of the restricted three body problem.

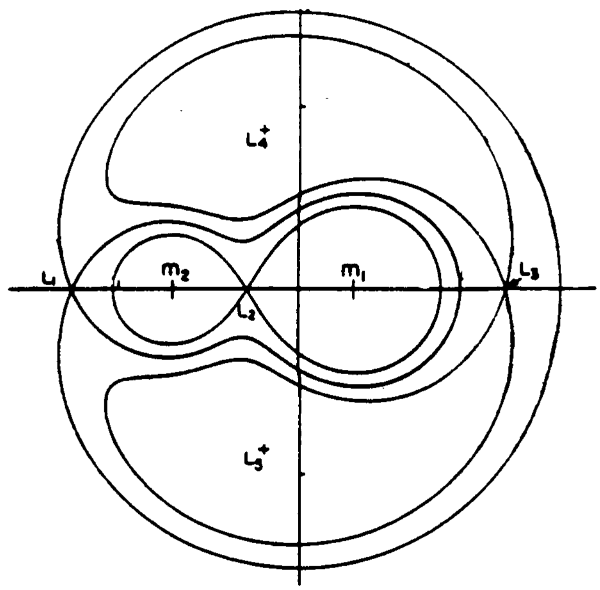
It is estimated that to fly to the Moon by way of L4 and L5 using minimum energy trajectories requires 758 m/s more delta V than by direct transfer from LEO to low lunar orbit (LLO). Consequently, it appears unlikely that L4 and L5 will be used as transportation nodes for a lunar base.

If a program is to be written to perform this analysis, it is recommended that a Lambert Problem solution be used as the "driver" for converging an "N" Body Problem integration. The latter would take into account the mass of the Moon and the perturbations of the Sun.

2.0 Introduction

L5, and its understated counterpart L4, are referred to as "Libration Points". They are also called Lagrange Points, in honor of J. L. Lagrange, who in the late 18th century derived the equations which proved their existence[1]. An object located at a libration point and orbiting the Earth at the Moon's angular velocity has no tendency to move away from that libration point since the forces acting on the object are in equilibrium; hence, libration points are also known as "Equilibrium Points". Five such points exist (Figure 2), three of which, L1, L2, and L3 are unstable. Any small perturbation of the object located at an unstable libration point would lead to the creation of forces which would accelerate the object further away from that point. L4 and L5 are stable; displaced objects are subjected to gravitational forces which act to return the object to the libration point. Spacecraft located at a stable libration point, in theory, do not need to expend fuel holding position or "station keeping". With minimal station keeping propellant requirements, L4 and L5 are predicted to be efficient places to park large space habitats and have been proposed as transportation node locations for Earth-Moon transfers.

Figure 2: Libration Points in Cislunar Space



It has been suggested that a space station at either L4 or L5 could act as a resupply and processing station for a lunar base. It would be the "middle man" in the cislunar transportation network.

If L4 and L5 are to be studied as possible locations for a cislunar transportation node, then the flight between these points and the Moon must be thoroughly understood. The mission plan and its design become the key issue in maximizing the resources to be transported to and from the Moon.

3.0 Mission Planning

L4 and L5 are located in the plane of motion of the Moon, one lunar orbit radius from both planetary bodies. The libration points lie at the open vertex of the equilateral triangle whose other vertices are occupied by the Earth (M_1) and the Moon (M_2), as shown in Figure 2. For this reason L4 and L5 are often called equilateral libration points (as opposed to the three collinear libration points which are all located on the Earth-Moon line). The equilateral libration points are located on opposite sides of Earth-Moon line. Following the notation of Szebehely[2], L4 is the libration point which is 60° from the Moon when measured clockwise about the Earth from the Earth-Moon line. L5, also 60° from the Moon, is measured counter-clockwise from the Earth-Moon line. When viewed from above, the Earth-Moon system rotates in the counter-clockwise direction; therefore, L4 always trails, and L5 always leads the Moon as it proceeds through its monthly orbit.

To perform a flight between the Moon and one of the equilateral libration points requires that a spacecraft accelerate away from the Moon or the libration point. In the process, it gains sufficient speed in a direction appropriate for arriving at the destination in the proper time frame. Upon reaching the destination, a breaking maneuver is executed; and the mission is complete. In order to provide acceleration and braking the vehicle will have to expend propellant. The amount of propellant required is related the total velocity change (also called "Delta V", or "Residual Velocity") experienced by the vehicle during acceleration and braking. The flight scenario described is known as a two burn transfer.

Normally, there is a need to make mid-course corrections in which adjustments to the velocity vector are made to remove dispersions inherent in the previous burns. The Delta Vs required for mid-course corrections are heavily influenced by mission and spacecraft specific details and the technology used. Readers interested in the preliminary design of such vehicles should include a contingency factor of 10 to 30 percent on the mid-course burns to account for technology and mission specific limitations which are difficult to determine in the early stages of design[3].

3.1 Plane Constraints

The three solution techniques discussed in this text all have the constraint of being restricted to the lunar orbit plane. This limits the lunar parking orbits to those with inclinations that are roughly equatorial. To enter parking orbits having inclinations that are non-equatorial requires another method of flight. Either a plane change burn be performed at the lunar sphere of influence, or an out-of-plane trajectory must be followed.

With reference to the work of Stump, and Simonds for direct transfers from LEO to LLO, the performance losses for entering a non-equatorial lunar parking orbit are insignificant as long as there is no constraint upon the location of the orbit's ascending node[4]. If, however, the ascending node is specified, then Delta V performance requirements can be considerably greater than the minimums discussed in this report.

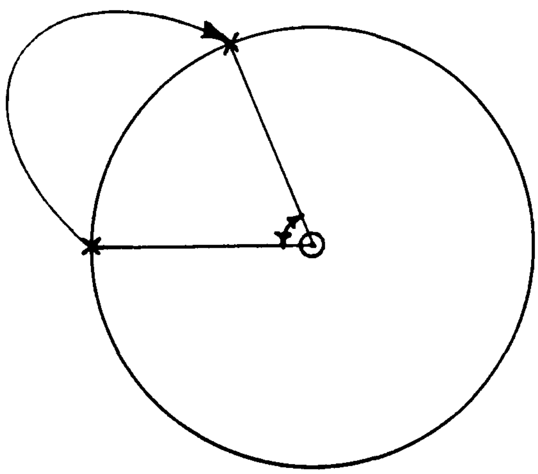
3.2 Trajectory Descriptions

The overall direction of travel is extremely important. Flights whose destination is leading the origin have an overall direction of travel which is counter-clockwise. There are two trajectories which fit this description: One starts at L4 and arrives at the Moon (L4 to Moon). The other begins at the Moon and arrives at L5 (Moon to L5). These flights are hereafter called "Type 1" flights. Flights which have an overall direction of travel which is clockwise, arrive at a destination which is trailing the origin. These are called "Type 2" flights. (L5 to Moon) and (Moon to L4) are examples of "Type 2" flights. The Delta Vs for "Type 1" flights are vastly different from those of "Type 2" flights. However, according to the Mirror Image Theorem[5], all flights within a given "Type" category have the same performance.

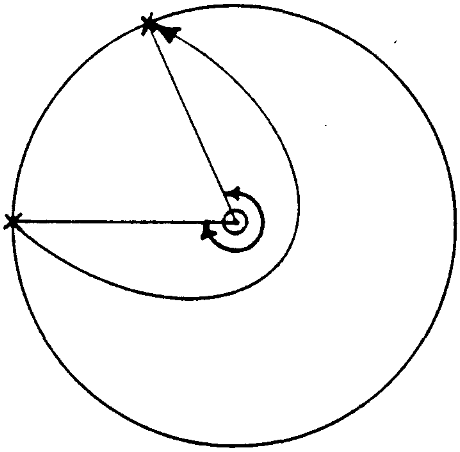
The overall direction of travel is not to be confused with the actual path that the spacecraft takes to get to the destination. When discussing the overall direction of travel, the location of the destination with respect to that of departure is the only important consideration. The actual path that a vehicle may take during its trajectory is completely independent of whether the flight is a "Type 1" or a "Type 2".

Given two positions and a time of flight there are two trajectories which satisfy these conditions. The Long Path trajectory goes around the primary body traversing an angle which is greater than 180°. The Short Path is a trajectory in which the angular motion is less than 180° (Figure 3). Finding the orbits which satisfy these trajectories is not a trivial task. The problem is called Lambert's Problem; and it is the next topic to be addressed.

Figure 3: Short and Long Path Trajectories with the Same Time of Flight



Short Path



Long Path

4.0 Lambert's Problem and The Gauss Solution

Situations often arise in which the initial position, the final position, and the time of travel between the two points are all known, but the orbit and the velocities at the two locations are not. This problem is called Lambert's Problem, named for the man who first postulated that it could be solved -- Johann Heinrech Lambert (1728 - 1779). Unfortunately, Lambert died unable to prove what he felt certain was correct. It remained for another great mathematician, Carl Friedrich Gauss (1777 - 1855) to derive the solution, and prove Lambert's Theorem true.

The program used to solve Lambert's Problem is written in universal variables to eliminate the singularity for parabolic trajectories. It is written with reference to Bate, Mueller, White[6], and has recently been converted to make use of Battin's Continued Fractions[7]. The difficulty with calculating strong hyperbolic orbits is removed by using a pure hyperbolic solution when the flight time becomes extremely short.

There are two independent solutions to Lambert's Problem. This is the result of having two paths that have the same flight time. For the most part, the two solutions can be characterized as prograde (travelling in the direction of the Moon) and retrograde (travelling opposite the direction of the Moon). Retrograde flights have higher Delta Vs since they must overcome the orbital velocity of the Moon in order to complete the transfer.

Gauss' solution identifies the inertial "space fixed" velocities that are required to complete the transfer flight in the flight time allowed. Since the libration point and the Moon are the same distance from the Earth in a circular orbit, then the inertial speed of the spacecraft at arrival is the same as that of departure; and the flight path angle at arrival is the negative of the flight path angle at departure. This is evident in Figures 4 and 5, which show the inertial speeds and flight path angles for "Type 1" and "Type 2" flights respectively. The inertial speed here is defined as speed relative to a non-rotating reference frame fixed at the center of the Earth.

Figure 4: Inertial Velocities for "Type 1" Flights

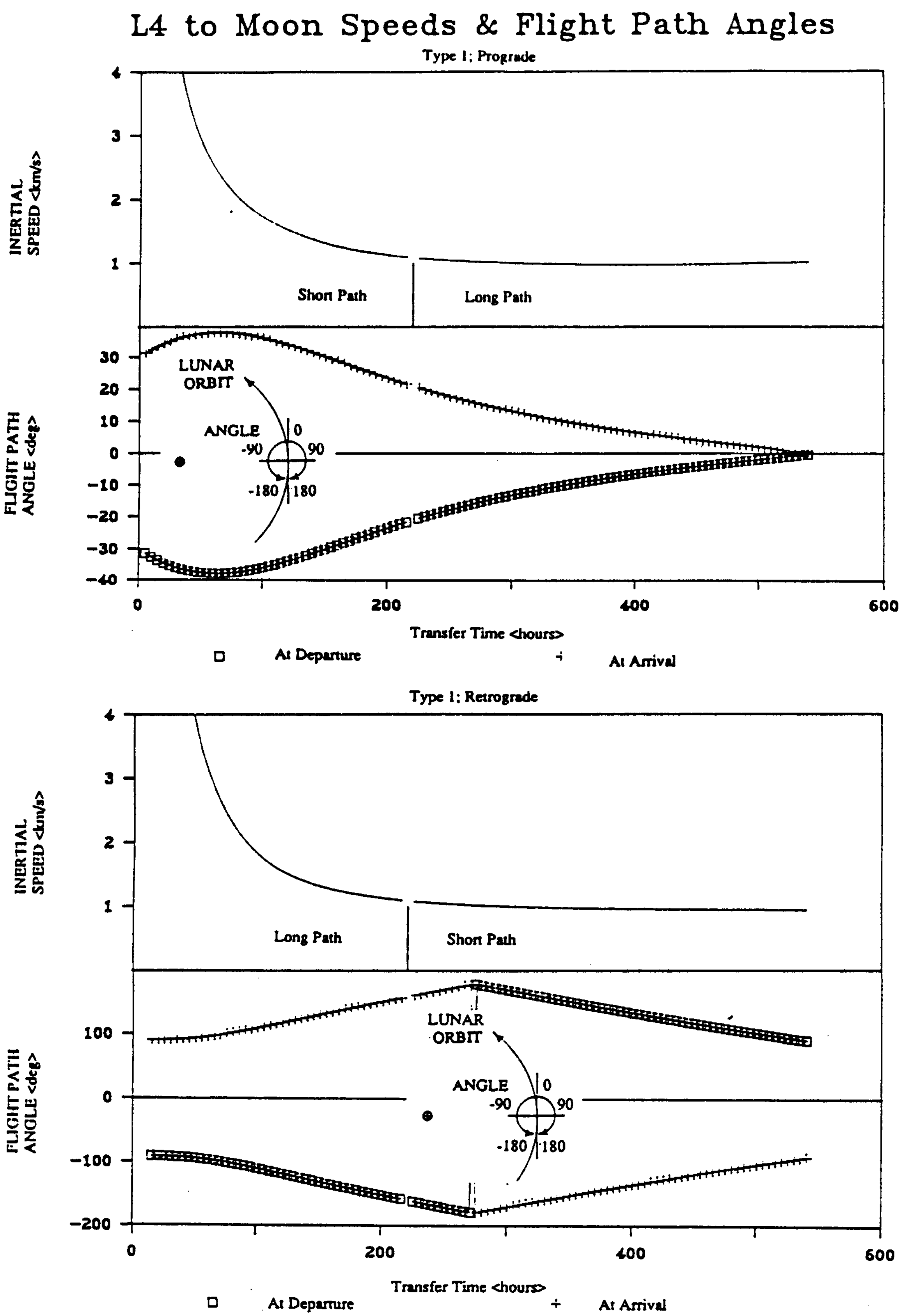
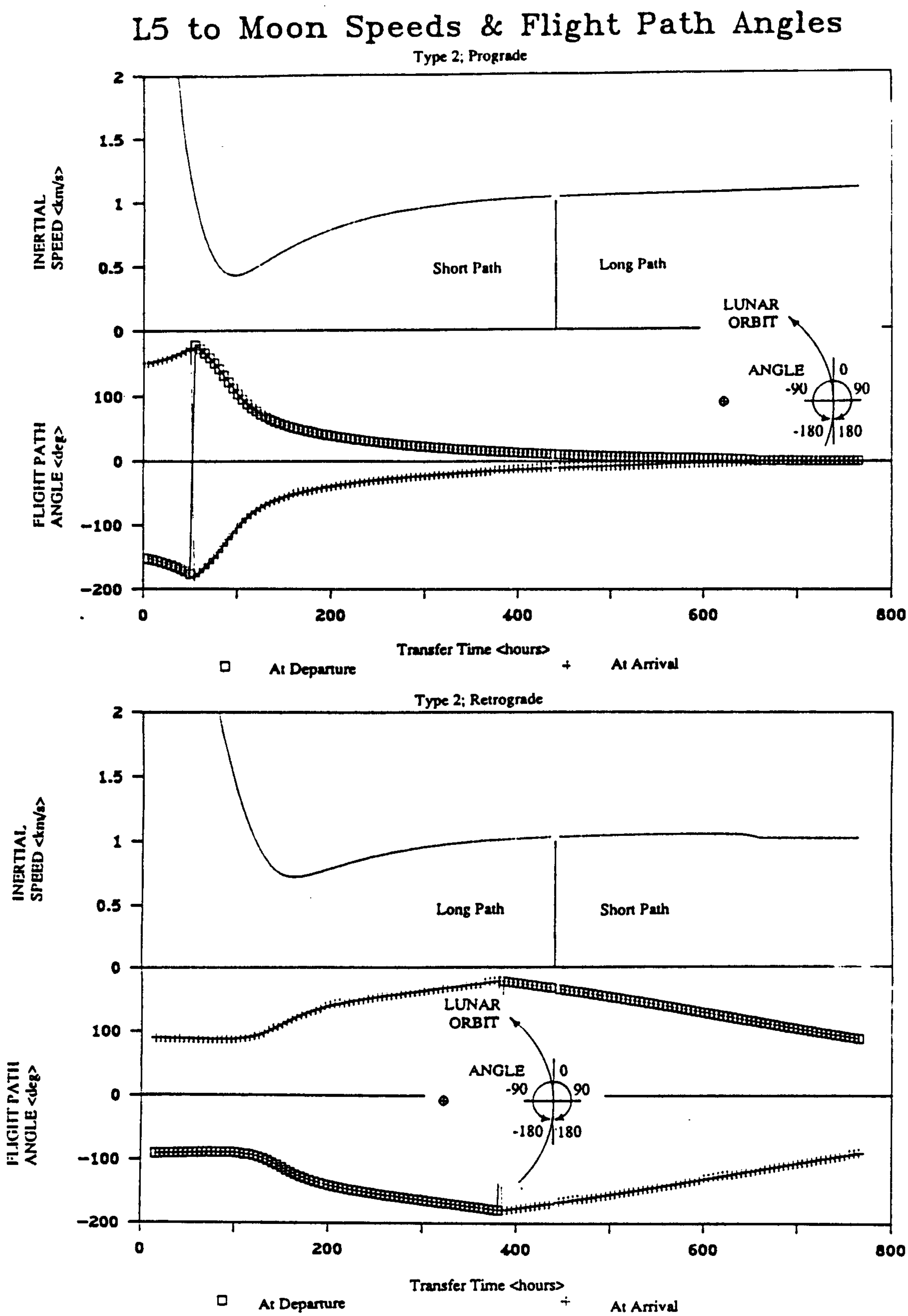


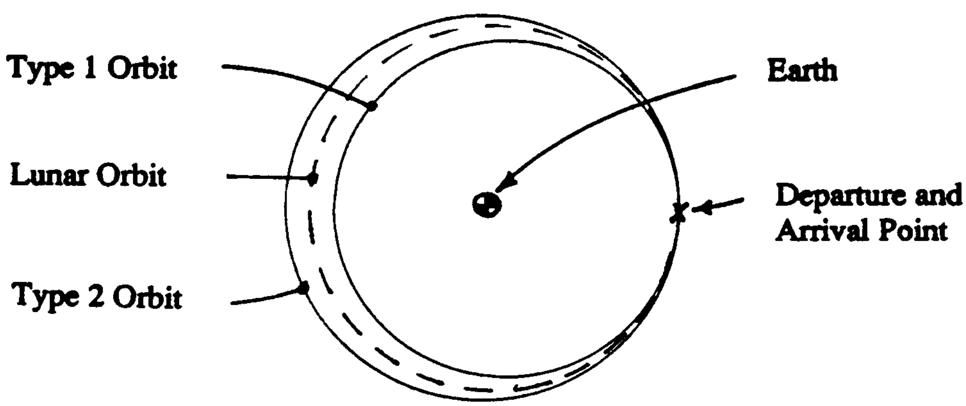
Figure 5: Inertial Velocities for "Type 2" Flights



These figures contain two graphs, one for each independent solution to Lambert's Problem. The prograde solution is characterized by trajectories which, for most transfer times, travel in the same direction that the Moon travels as it orbits the Earth. The flight path angles for this solution are usually less than 90° and greater than -90°. Trajectories which travel opposite the direction of the Moon are indicative of the retrograde solution. These transfers normally have flight path angles which are greater than 90° and less than -90°.

When the spacecraft reaches its destination which, at the time of arrival, is located at the same point in space from which the spacecraft originated, then the transfer trajectory is a full orbit Hohmann transfer (FOHT) -- see Figure 6. For FOHTs, the time required to transfer is equal to the period of the transfer orbit. For "Type 1" flights where the destination is leading the origin, a FOHT requires 545 hours (22.7 days) to complete. Since the period of the transfer orbit is 16% shorter than the lunar orbit period of 655 hours (27.3 days), the spacecraft arrives 60° ahead of the object from which it originated. For example, if the spacecraft departs from the Moon on a "Type 1" FOHT, then it will arrive at L5 545 hours later, 60° ahead of the Moon. In "Type 2" flights the FOHT is 765 hours (31.9 days).

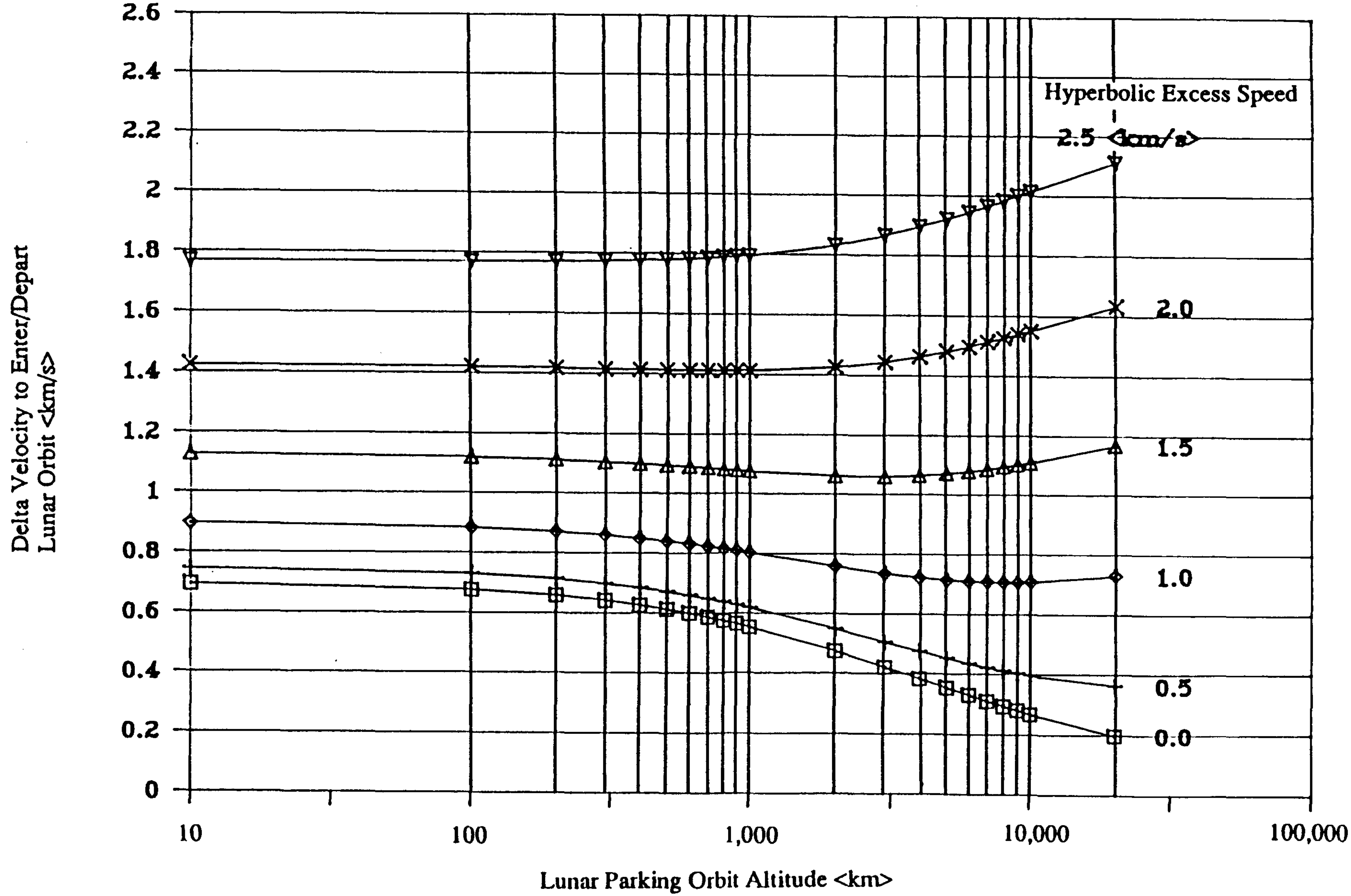
Figure 6: Full Orbit Hohmann Transfers



Having calculated the inertial transfer velocities which solve Lambert's Problem, it is possible to determine the Delta V or Residual Velocity required at the Moon and the Libration point. At the libration point, the Delta V is calculated by taking the vector difference between the orbital velocity and the transfer velocity. The orbital velocity at the libration points is equal to the Moon's orbital velocity, which is an average 1.0233 kilometers per second <km/s> perpendicular to the position vector. At the Moon, this difference is known as the hyperbolic excess speed. It represents the excess velocity remaining when the vehicle escapes from the lunar gravity field, or the spacecraft's speed relative to the Moon before it reaches the lunar sphere of influence. The Delta V at the lunar parking orbit is dependent upon the altitude of the parking orbit. Figure 7 illustrates the relationship between hyperbolic excess speed, Delta V, and the lunar parking orbit altitude.

All of the charts and graphs in this report are based upon a low lunar parking orbit of 100 km altitude.

Figure 7: Velocity Change Required at the Lunar Parking Orbit



Using the information in Figures 4, 5, and 7 it is possible to construct plots of the Velocity Change Requirements (Delta V) for the Moon and the libration point as a function of transfer time. Figures 8 and 9 give the total Delta V broken down into the two burns. By combining the data in these charts, the total Delta V for the entire flight can be calculated and is shown in Figure 10.

These plots indicate that the minimum Delta V requirements occur in the prograde solution of Lambert's Problem as it approaches the full orbit Hohmann transfer. Therefore, the prograde full orbit Hohmann transfer is referred to as the minimum energy transfer. For "Type 1" flights, the Delta Vs at the Moon and the libration point are 677 m/s and 76 m/s respectively. "Type 2" flights have Delta Vs of 676 m/s and 49 m/s for the Moon and the libration point.

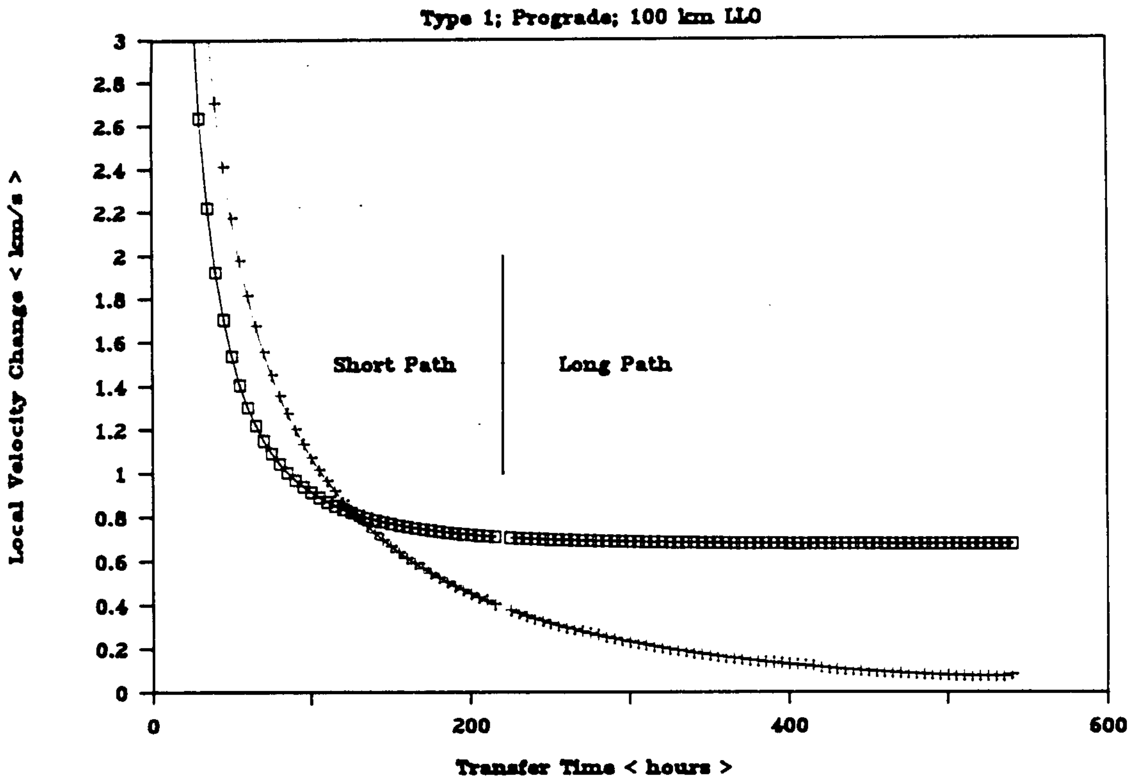
The Hohmann solution for a full orbit Hohmann transfer requiring 545 hours of flight time yields an inertial velocity at departure and arrival of 1.091 km/s. The transfer velocity vector is aligned with the lunar orbital velocity vector. The residual velocity can be calculated by subtracting the lunar orbital velocity from the transfer velocity, and is:

$$\begin{aligned} 68 \text{ m/s} = \quad & V_{transfer} - V_{lunar\ orbit} \\ & 1{,}091 \text{ m/s} - 1{,}023 \text{ m/s} \end{aligned}$$

For a full orbit Hohmann transfer the solution of Lambert's Problem should equal the Hohmann predictions, since the same assumptions apply to both solutions. However, as already stated, Lambert's Problem results in a residual velocity of 76 m/s for this flight. This is a 12% error in the Hohmann residual velocity prediction of 68 m/s. This error is the probable result of a singularity which is inherent to Lambert Problem's for orbits traversing 360° of angular motion. Full orbit Hohmann transfers are, by definition, 360° transfer orbits.

One of the assumptions of Lambert's Problem is that gravity is uniformly distributed about a single central force body called the Primary. Having negligible mass, the secondary body is expected to travel along either of the orbits which satisfy the Gauss solution. This is a standard Two Body Problem in which the Earth corresponds to the primary body, and the spacecraft represents the secondary. However, the Single Central Force Body assumption is not strictly correct when considering the fact that the Moon also has gravity. This results in a non-uniform gravity field, and leads to errors in the flight time calculations of the Gauss' solution. In order to analyze and adjust the data in the presence of these errors, a comparison is made with a higher order solution called the Restricted Three Body Problem.

Figure 8: Local Delta V Requirements for "Type 1" Flights



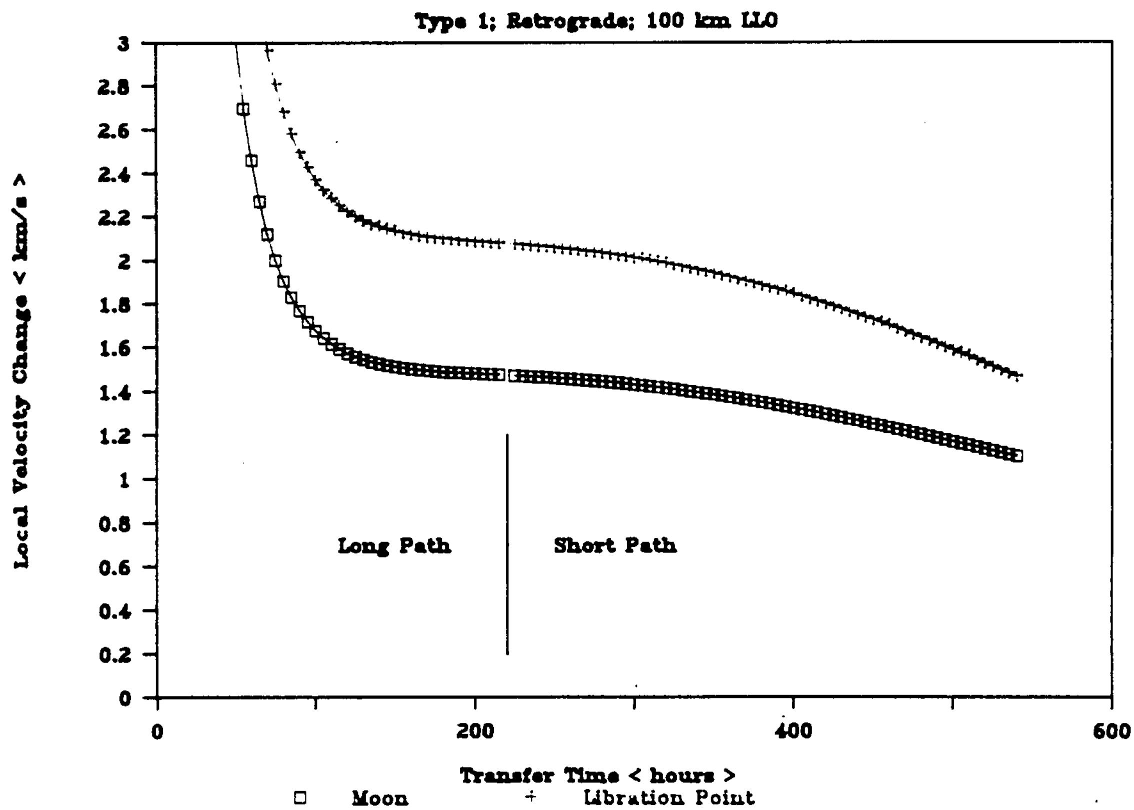
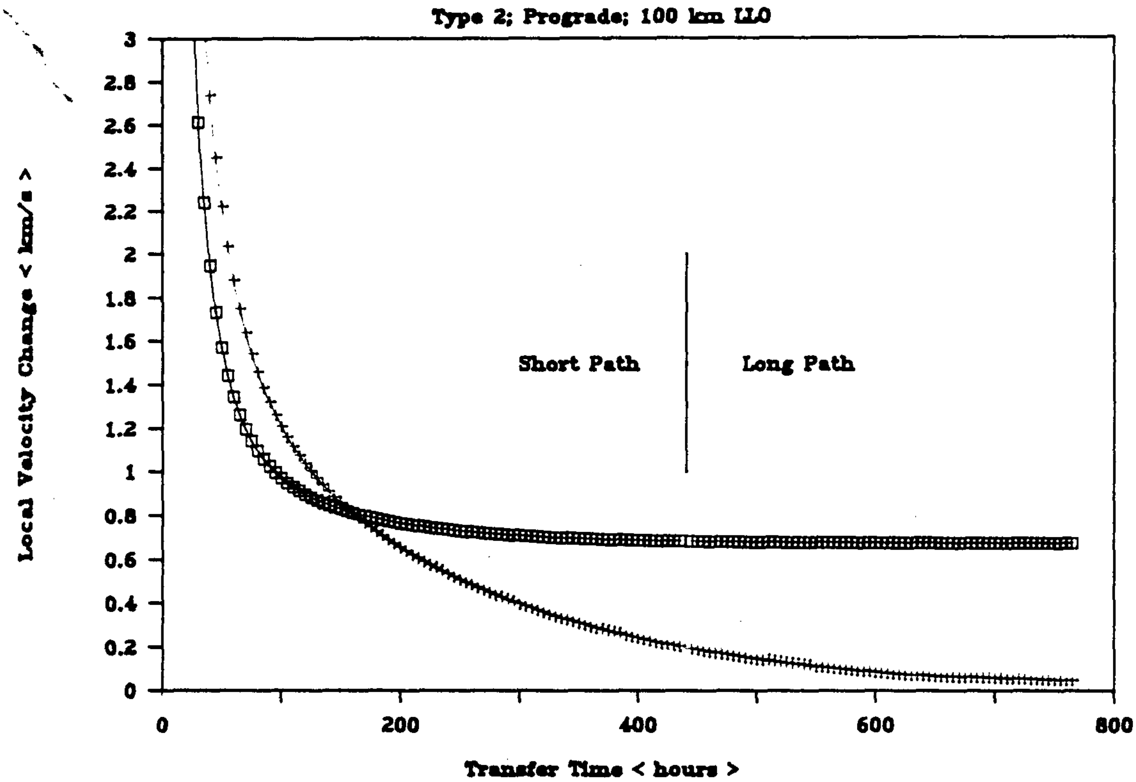


Figure 9: Local Delta V Requirements for "Type 2" Flights



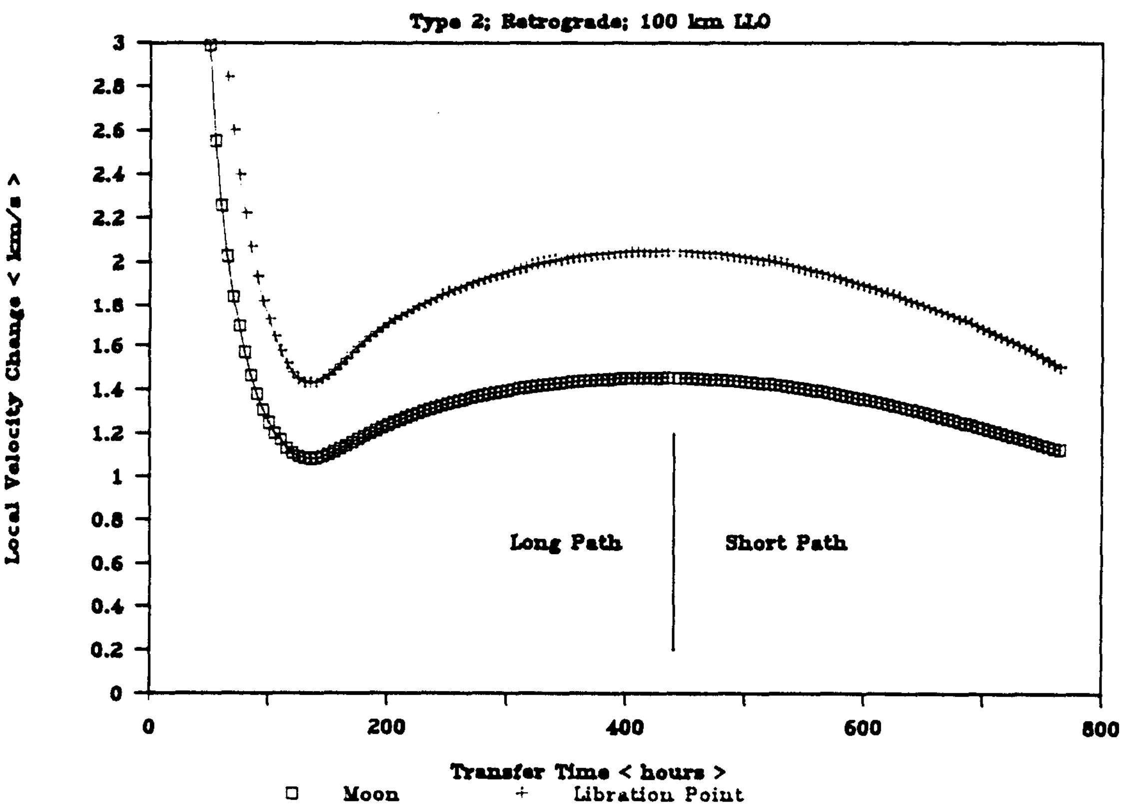
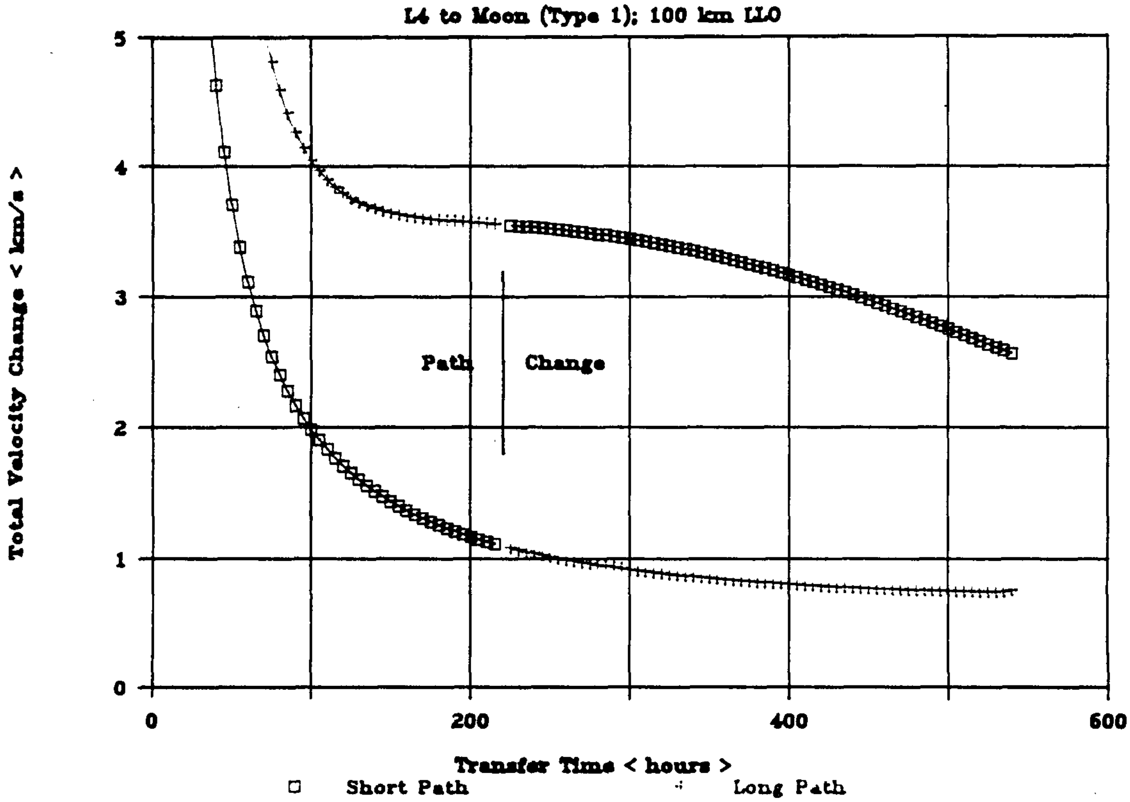
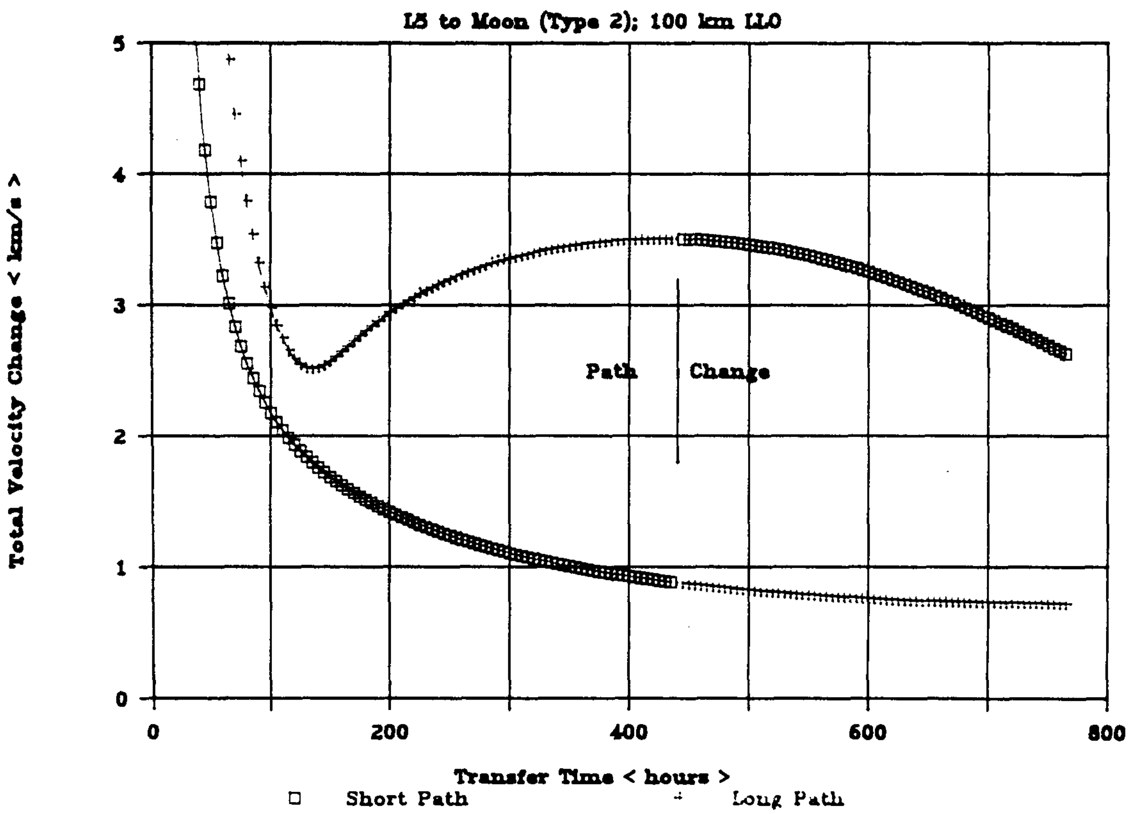


Figure 10: Total Velocity Change Requirements





5.0 The Restricted Three Body Problem

Many great scientists and mathematicians have contributed to our modern day understanding of the Restricted Three Body Problem. Topping the list are men such a Euler, Jacobi, and Poincaré. In 1760, Euler disclosed his lunar theory in which he presented the problem of two central force bodies acting on a third. Later, Jacobi discovered the famous energy integral which provides the relationship between position and velocity. By studying the problem of a small satellite orbiting a much larger parent body, Poincaré significantly improved the techniques of qualitative analysis as it applies to the Restricted Three Body Problem. There have been others such as Lagrange, Hill, Levi-Civita, and Sundman. Therefore, it cannot be said that the Restricted Three Body Problem is the idea of just one man. It is actually many ideas belonging to many men.

The Three Body Problem is a problem of two primary bodies both having forces which act upon the motion of a third body. In general, the problem is unsolvable in closed form. But, by adding some well chosen restrictions, useful relationships can be derived. In formulating the Restricted Three Body Problem, the following constraints are applied[2]:

1. The two primary bodies must be in circular orbits about one another.

2. The third body moves in the plane containing the orbit of the two primaries.

3. The third body is of negligible mass, and has no influence upon the motion of the primaries.

To describe the Earth-Moon system in terms of the Restricted Three Body Problem, the Earth and Moon are the two primary bodies. The spacecraft is the third body having negligible mass and no influence on the motion of the Earth or Moon. The spacecraft is traveling in the lunar orbit plane between the equilateral libration points and the Moon. The Moon's orbit about the Earth has an eccentricity of 0.0549 which is assumed to be circular. The circular orbit approximation is the largest source of error when the Restricted Three Body Problem is applied to the Earth-Moon system.

Studies of the Restricted Three Body Problem by Broucke[5] have revealed that the transfer times between the moon and the equilateral libration points are considerably shorter than those predicted by Gauss' solution of Lambert's Problem. Proof of this can be seen in Figures 11 and 12 which show the results of Broucke next to the solution of Lambert. From the information presented in the error analysis, it would appear that the Broucke solution passes through a minimum energy transfer at approximately 395 hours (16.5 days) for "Type 1" flights, and 565 hours (23.5 days) for "Type 2" flights. The Delta V required for the minimum energy transfer is 677 m/s at the 100 km low lunar orbit for both "Type 1" and "Type 2" flights. At the libration point, the residual velocity is 80 m/s for "Type 1" flights, and 60 m/s for "Type 2" flights. The values at the libration points are within 18% and 25% of the theoretical Hohmann solutions of 68 m/s and 49 m/s respectively. But the flight times differ from the Gauss solution by 150 hours for the "Type 1" flights and 200 hours for "Type 2" flights. These are large differences, and are undoubtedly the result of lunar gravity.

Table 1 is a summary of the performance predictions using the three methods previously discussed.

Table 1: Performance for Minimum Energy Transfers

Burn Location	Lambert	Three Body	Hohmann
Libration Point Residual Velocity < m/s > "Type 1" Flight	76	80	68
Libration Point Residual Velocity < m/s > "Type 2" Flight	49	60	49
Low Lunar Orbit (Parking) Delta V < m/s >	676	677	677
L4 to the Moon Flight Time < hours >	545	395	
L5 to the Moon Flight Time < hours >	765	565	

The flight time error is not nearly as noticeable for the shorter transfer times (less than 250 hours). Therefore the Lambert Problem solution may be viewed as an acceptable approximation for trajectories in this regime. However, the large errors inherent in the long flight time trajectories of Lambert's Problem makes the Three Body Problem solution of Broucke the preferred answer.

If the assumption is made that Broucke's solution is more correct by virtue of its being a higher order solution, then the total minimum Delta V required to transfer between the Moon and the libration points is 757 m/s for "Type 1" flights and 737 m/s for "Type 2" flights. It requires 833 m/s to transfer back to the Earth from either L4 or L5. 3.097 km/s is necessary to circularize into a 400 km orbit at Earth. If the Delta V for "Type 1" and "Type 2" flights are averaged, then the total Delta V for the whole flight is 4.677 km/s. But, what is the Delta V if the flight is made directly between the Earth and the Moon? For a hyperbolic excess speed of 833 m/s, the Delta V required at a 100 km low lunar orbit is 822 m/s. The Delta V at the Earth is still 3.097 km/s yielding a total Delta V of 3.919 km/s. This means that by making a direct transfer between the Earth and the Moon, rather than stopping at L4 or L5, it is possible to save 758 m/s in required velocity change. In addition, long flight times on the order of 25 to 30 days are associated with the L4/L5 minimum Delta V trajectories. Direct transfers from the Earth to LLO typically require only 3 to 5 days to complete.

Table 2: Cislunar Delta V Summary

Delta V Location	L4/L5 Transfer (E-L4/L5-M)	Direct Transfer (Earth-Moon)
Earth Parking Orbit	3,097 m/s	3,097 m/s
Libration Point (Arrival)	833 m/s	-
Libration Point (Departure)	~70 m/s	-
Lunar Parking Orbit (LLO)	677 m/s	822 m/s
Total Velocity Change	4,677 m/s	3,919 m/s

The ultimate results of making direct transfers are lower fuel requirements, smaller spacecraft, and shorter flight times. For these reasons it is unlikely that L4 or L5 will be used as a transportation node for a lunar base.

If in the future, a simulation is written to solve this problem, the best programming technique would be to use a Gauss solution as a "driver" program for converging an "N" Body Problem integration scheme. The "N" Body Problem would provide for lunar gravity and solar perturbations.

Figure 11: Error Analysis of "Type 1" Trajectories

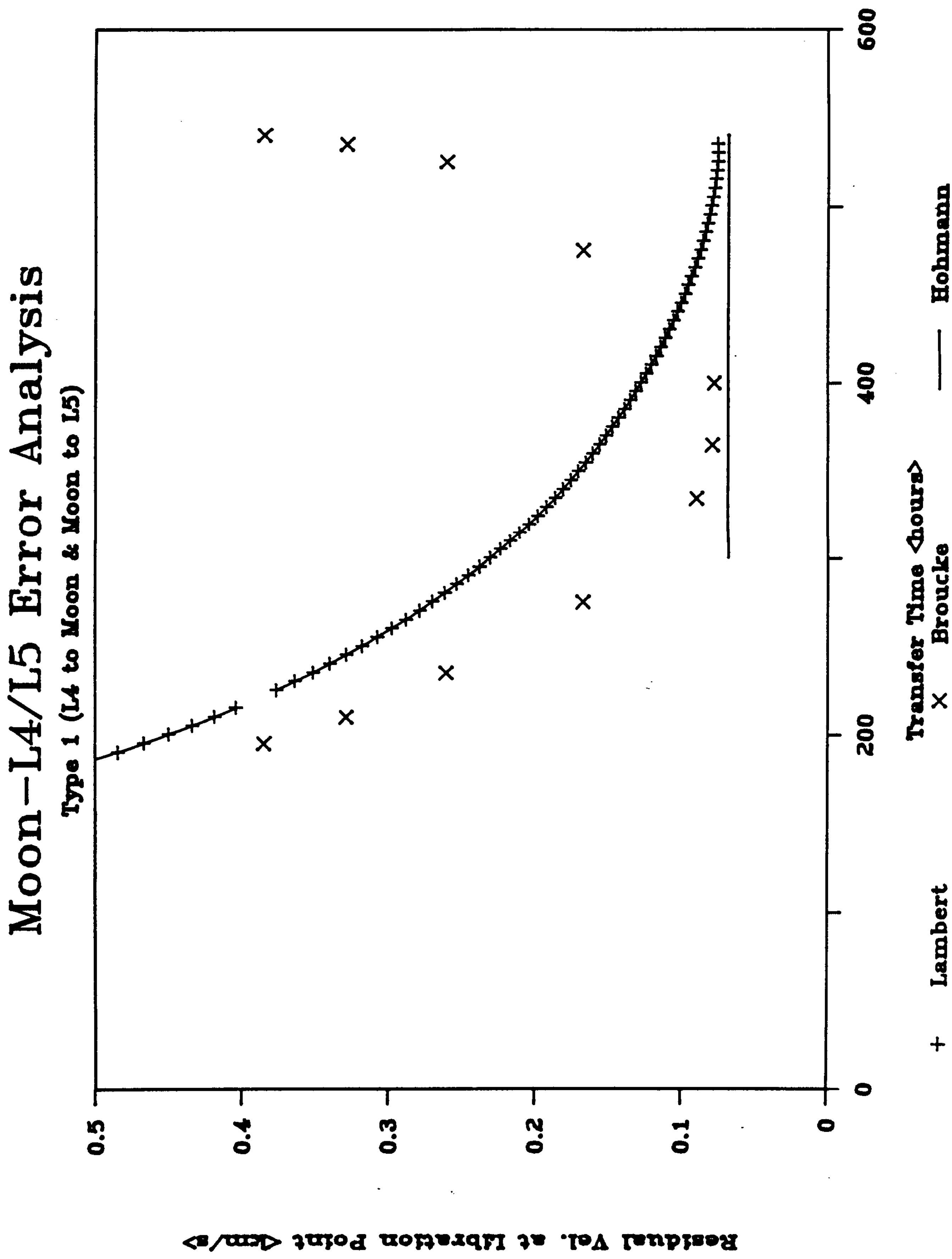
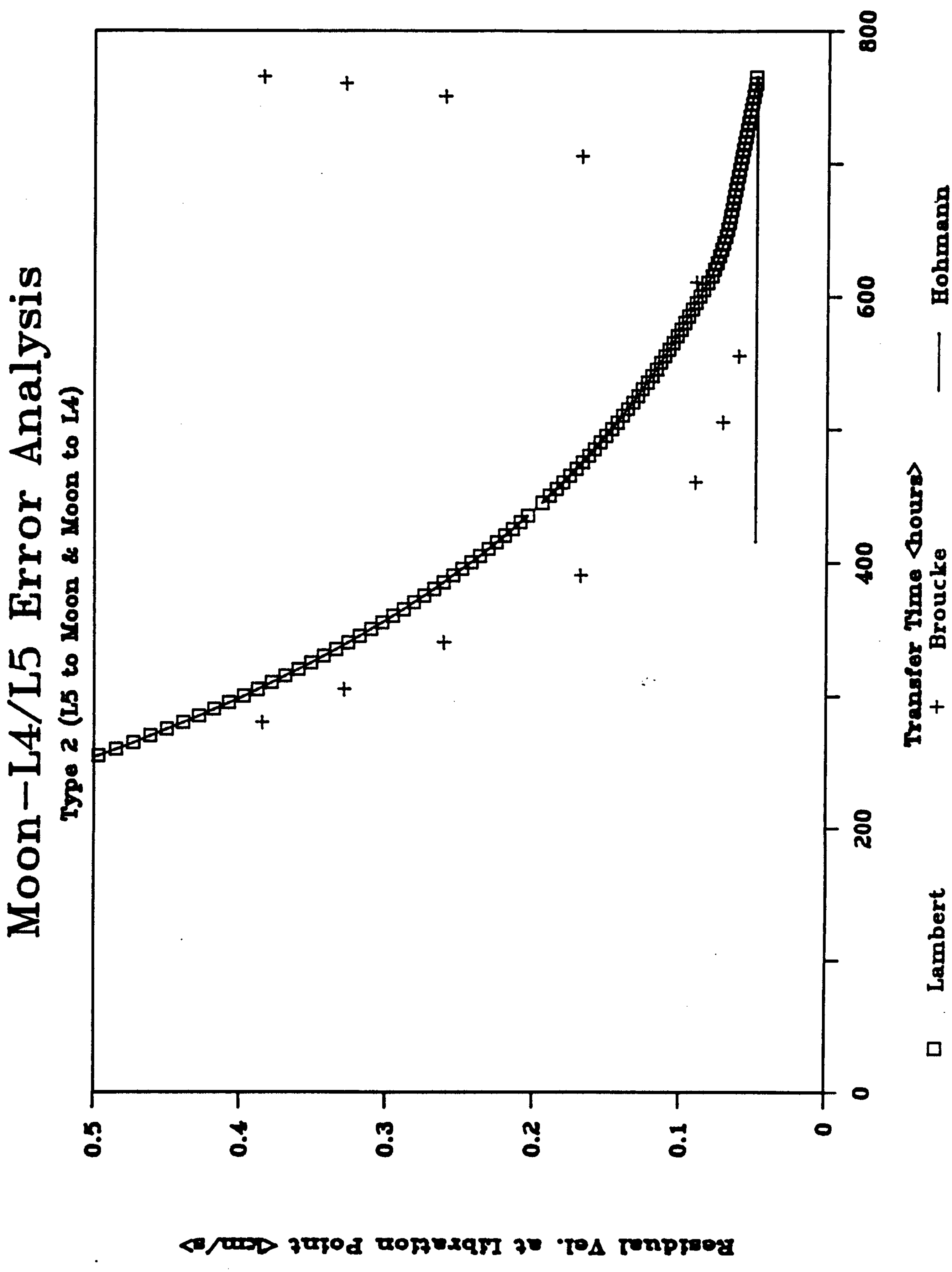


Figure 12: Error Analysis of "Type 2" Trajectories



6.0 Appendix: Inertial Velocity Tables for "Type 1" and "Type 2" Flights

"Type 1" Inertial Velocity Components

Transfer Flight Time	Short Path				Long Path			
	Origin		Destination		Origin		Destination	
	X	Y	X	Y	X	Y	X	Y
< hours >	< km/s >	< km/s >	< km/s >	< km/s >	< km/s >	< km/s >	< km/s >	< km/s >
5	-11.5480	18.99355	-11.5965	18.96396	-14.0801	0.035687	8.742345	-11.0373
10	-6.19160	9.734132	-6.28853	9.671797	-10.3402	0.045628	6.81579	-7.77611
15	-4.39276	6.639821	-4.53780	6.541555	-14.0395	-0.04992	5.251905	13.02027
20	-3.48191	5.086943	-3.67462	4.949525	-10.3479	-0.07110	3.439304	9.759983
25	-2.92498	4.150684	-3.16479	3.970863	-8.17166	-0.09433	2.380332	7.817866
30	-2.56028	3.542047	-2.84491	3.317772	-6.71948	-0.11990	1.688324	6.505032
35	-2.28531	3.096458	-2.61428	2.824223	-5.68096	-0.14786	1.207989	5.553017
40	-2.07325	2.761969	-2.44500	2.439019	-4.90233	-0.17813	0.861733	4.829285
45	-1.90302	2.501871	-2.31572	2.125623	-4.29809	-0.21054	0.605983	4.260363
50	-1.76204	2.294122	-2.21360	1.862195	-3.81675	-0.24484	0.414114	3.802117
55	-1.64234	2.124674	-2.13039	1.634922	-3.42536	-0.28070	0.268740	3.426319
60	-1.53865	1.984141	-2.06058	1.434669	-3.10170	-0.31769	0.157895	3.113935
65	-1.44736	1.866001	-2.00032	1.255192	-2.83024	-0.35540	0.073001	2.851534
70	-1.36590	1.765575	-1.94686	1.092097	-2.59968	-0.39338	0.007727	2.629264
75	-1.29244	1.679411	-1.89816	0.942229	-2.40162	-0.43123	-0.04268	2.439660
80	-1.22559	1.604900	-1.85270	0.803277	-2.22968	-0.46859	-0.08184	2.276919
85	-1.16432	1.540033	-1.80933	0.673527	-2.07891	-0.50516	-0.11252	2.136446
90	-1.10782	1.483231	-1.76717	0.551693	-1.94544	-0.54072	-0.13682	2.014549
95	-1.05548	1.433237	-1.72552	0.436798	-1.82622	-0.57508	-0.15635	1.908236
100	-1.00678	1.389035	-1.68386	0.328094	-1.71880	-0.60815	-0.17234	1.815059
105	-0.96132	1.349795	-1.64178	0.225008	-1.62123	-0.63983	-0.18573	1.733004
110	-0.91876	1.314831	-1.59898	0.127095	-1.53193	-0.67009	-0.19724	1.660409
115	-0.87882	1.283574	-1.55522	0.034008	-1.44961	-0.69892	-0.20740	1.595891
120	-0.84126	1.255544	-1.51034	-0.05452	-1.37322	-0.72632	-0.21662	1.538296
125	-0.80587	1.230337	-1.46421	-0.13870	-1.30188	-0.75230	-0.22522	1.486656
130	-0.77247	1.207608	-1.41675	-0.21871	-1.23489	-0.77690	-0.23343	1.440156
135	-0.74091	1.187064	-1.36793	-0.29467	-1.17164	-0.80014	-0.24142	1.398106
140	-0.71104	1.168452	-1.31772	-0.36669	-1.11164	-0.82206	-0.24933	1.359919
145	-0.68275	1.151553	-1.26614	-0.43485	-1.05446	-0.84270	-0.25726	1.325096
150	-0.65591	1.136180	-1.21322	-0.49921	-0.99976	-0.86210	-0.26527	1.293206
155	-0.63043	1.122168	-1.15900	-0.55983	-0.94723	-0.88028	-0.27342	1.263881
160	-0.60621	1.109373	-1.10354	-0.61675	-0.89661	-0.89729	-0.28173	1.236802
165	-0.58318	1.097670	-1.04692	-0.67002	-0.84768	-0.91316	-0.29024	1.211693
170	-0.56124	1.086949	-0.98921	-0.71965	-0.80026	-0.92791	-0.29895	1.188314
175	-0.54034	1.077112	-0.93051	-0.76569	-0.75419	-0.94158	-0.30786	1.166455
180	-0.52041	1.068075	-0.87092	-0.80815	-0.70933	-0.95420	-0.31699	1.145934
185	-0.50139	1.059759	-0.81054	-0.84706	-0.66555	-0.96578	-0.32632	1.126590
190	-0.48322	1.052099	-0.74947	-0.88244	-0.62275	-0.97635	-0.33585	1.108283
195	-0.46585	1.045035	-0.68783	-0.91433	-0.58085	-0.98593	-0.34557	1.090889
200	-0.44924	1.038511	-0.62574	-0.94274	-0.53977	-0.99454	-0.35546	1.074299
205	-0.43334	1.032482	-0.56332	-0.96771	-0.49943	-1.00220	-0.36553	1.058415
210	-0.41810	1.026902	-0.50068	-0.98927	-0.45979	-1.00893	-0.37574	1.043153
215	-0.40350	1.021735	-0.43795	-1.00744	-0.42079	-1.01473	-0.38610	1.028437
220	-0.38239	0.718646	-0.39659	-0.14408	-0.38950	-0.73441	-0.37526	0.109789
225	-0.34455	-1.02365	-0.40720	1.000382	-0.37606	1.012501	-0.31272	-1.03382
230	-0.30725	-1.02678	-0.41791	0.986930	-0.36315	1.008374	-0.25047	-1.04209
235	-0.27045	-1.02904	-0.42871	0.973796	-0.35075	1.004540	-0.18862	-1.04716
240	-0.23413	-1.03045	-0.43960	0.960937	-0.33882	1.000974	-0.12730	-1.04906
245	-0.19828	-1.03101	-0.45057	0.948316	-0.32735	0.997656	-0.06662	-1.04787
250	-0.16288	-1.03074	-0.46159	0.935899	-0.31630	0.994566	-0.00672	-1.04363

255	-0.12793	-1.02965	-0.47267	0.923654	-0.30566	0.991688	0.052280	-1.03640
260	-0.09340	-1.02774	-0.48380	0.911553	-0.29540	0.989004	0.110282	-1.02627
265	-0.05930	-1.02503	-0.49496	0.899573	-0.28551	0.986502	0.167161	-1.01329
270	-0.02562	-1.02153	-0.50616	0.887688	-0.27597	0.984166	0.222806	-0.99754
275	0.007633	-1.01724	-0.51738	0.875880	-0.26675	0.981986	0.277106	-0.97911
280	0.040475	-1.01218	-0.52861	0.864127	-0.25785	0.979949	0.329955	-0.95808
285	0.072897	-1.00635	-0.53987	0.852414	-0.24925	0.978047	0.381251	-0.93453
290	0.104899	-0.99978	-0.55113	0.840722	-0.24094	0.976268	0.430894	-0.90856
295	0.136475	-0.99245	-0.56240	0.829037	-0.23289	0.974605	0.478788	-0.88025
300	0.167621	-0.98440	-0.57367	0.817344	-0.22510	0.973049	0.524841	-0.84972
305	0.198332	-0.97563	-0.58493	0.805629	-0.21755	0.971593	0.568967	-0.81706
310	0.228602	-0.96614	-0.59619	0.793880	-0.21024	0.970231	0.611081	-0.78238
315	0.258423	-0.95596	-0.60745	0.782084	-0.20315	0.968955	0.651106	-0.74579
320	0.287788	-0.94509	-0.61869	0.770228	-0.19628	0.967760	0.688969	-0.70739
325	0.316689	-0.93355	-0.62991	0.758301	-0.18960	0.966640	0.724599	-0.66730
330	0.345117	-0.92135	-0.64112	0.746292	-0.18312	0.965592	0.757934	-0.62565
335	0.373063	-0.90850	-0.65232	0.734188	-0.17683	0.964608	0.788914	-0.58254
340	0.400519	-0.89502	-0.66349	0.721980	-0.17071	0.963686	0.817487	-0.53809
345	0.427476	-0.88091	-0.67464	0.709656	-0.16475	0.962822	0.843604	-0.49244
350	0.453923	-0.86620	-0.68576	0.697204	-0.15896	0.962011	0.867224	-0.44570
355	0.479852	-0.85090	-0.69685	0.684615	-0.15332	0.961249	0.888309	-0.39801
360	0.505254	-0.83503	-0.70791	0.671878	-0.14782	0.960535	0.906829	-0.34948
365	0.530119	-0.81859	-0.71893	0.658981	-0.14247	0.959864	0.922758	-0.30025
370	0.554438	-0.80161	-0.72992	0.645913	-0.13725	0.959233	0.936077	-0.25045
375	0.578202	-0.78411	-0.74086	0.632664	-0.13215	0.958640	0.946771	-0.20020
380	0.601403	-0.76609	-0.75176	0.619223	-0.12717	0.958083	0.954833	-0.14963
385	0.624033	-0.74758	-0.76261	0.605578	-0.12231	0.957559	0.960262	-0.09888
390	0.646083	-0.72859	-0.77339	0.591720	-0.11756	0.957065	0.963060	-0.04807
395	0.667546	-0.70915	-0.78412	0.577637	-0.11292	0.956599	0.963237	0.002671
400	0.688414	-0.68926	-0.79477	0.563318	-0.10837	0.956160	0.960810	0.053215
405	0.708682	-0.66895	-0.80535	0.548753	-0.10392	0.955746	0.955799	0.103436
410	0.728341	-0.64824	-0.81585	0.533931	-0.09955	0.955354	0.948230	0.153208
415	0.747387	-0.62714	-0.82625	0.518842	-0.09528	0.954984	0.938138	0.202409
420	0.765813	-0.60567	-0.83655	0.503474	-0.09108	0.954633	0.925560	0.250916
425	0.783616	-0.58386	-0.84675	0.487819	-0.08696	0.954299	0.910539	0.298610
430	0.800790	-0.56172	-0.85682	0.471865	-0.08291	0.953982	0.893125	0.345376
435	0.817333	-0.53928	-0.86676	0.455604	-0.07894	0.953680	0.873372	0.391098
440	0.833239	-0.51654	-0.87656	0.439026	-0.07502	0.953391	0.851340	0.435665
445	0.848508	-0.49353	-0.88620	0.422122	-0.07117	0.953114	0.827092	0.478969
450	0.863137	-0.47028	-0.89568	0.404883	-0.06737	0.952849	0.800699	0.520904
455	0.877125	-0.44680	-0.90497	0.387301	-0.06363	0.952593	0.772234	0.561370
460	0.890470	-0.42310	-0.91406	0.369368	-0.05993	0.952345	0.741777	0.600267
465	0.903173	-0.39921	-0.92295	0.351077	-0.05628	0.952105	0.709409	0.637503
470	0.915233	-0.37516	-0.93160	0.332423	-0.05268	0.951871	0.675219	0.672988
475	0.926653	-0.35095	-0.94002	0.313397	-0.04911	0.951641	0.639297	0.706635
480	0.937433	-0.32661	-0.94816	0.293996	-0.04557	0.951416	0.601738	0.738363
485	0.947575	-0.30216	-0.95603	0.274214	-0.04207	0.951193	0.562641	0.768097
490	0.957083	-0.27761	-0.96360	0.254049	-0.03859	0.950971	0.522108	0.795763
495	0.965961	-0.25299	-0.97085	0.233495	-0.03514	0.950750	0.480244	0.821296
500	0.974211	-0.22831	-0.97777	0.212553	-0.03170	0.950529	0.437156	0.844632
505	0.981839	-0.20359	-0.98432	0.191220	-0.02828	0.950304	0.392956	0.865716
510	0.988849	-0.17886	-0.99049	0.169496	-0.02487	0.950077	0.347756	0.884494
515	0.995249	-0.15412	-0.99626	0.147382	-0.02147	0.949843	0.301673	0.900919
520	1.001043	-0.12940	-1.00161	0.124879	-0.01807	0.949598	0.254822	0.914947
525	1.006238	-0.10471	-1.00651	0.101990	-0.01468	0.949329	0.207324	0.926530
530	1.010843	-0.08006	-1.01094	0.078720	-0.01128	0.948972	0.159299	0.935574

535	1.014864	-0.05549	-1.01488	0.055074	-0.00793	0.948055	0.110871	0.941583
540	1.018310	-0.03099	-1.01830	0.031057	-0.00507	0.938403	0.062201	0.936353
545	0.657900	-0.83089	-0.47080	0.949511	0.106327	1.052566	0.997328	-0.35289

Transfer Flight Time < hours >	"Type 2" Inertial Velocity Components — Short Path — Origin X < km/s >	Short Path — Origin Y < km/s >	Short Path — Destination X < km/s >	Short Path — Destination Y < km/s >	Long Path — Origin X < km/s >	Long Path — Origin Y < km/s >	Long Path — Destination X < km/s >	Long Path — Destination Y < km/s >
5	-9.77709	-17.9698	-9.82563	-17.9433				
10	-4.42513	-8.70932	-4.52207	-8.65938				
15	-2.63378	-5.61317	-2.77888	-5.54277	-14.0801	0.035687	8.742345	-11.0373
20	-1.73352	-4.05781	-1.92643	-3.96985	-10.3402	0.045628	6.81579	-7.77611
25	-1.15	-3.1	-1.4	-3	-8.15306	0.05419	5.674774	-5.85425
30	-0.8	-2.45	-1.1	-2.35	-6.69114	0.061643	4.893851	-4.56349
35	-0.56699	-2.03493	-0.89984	-1.9112	-5.64109	0.068023	4.315885	-3.63314
40	-0.37061	-1.68912	-0.74886	-1.55874	-4.84876	0.07333	3.864165	-2.92986
45	-0.21767	-1.41641	-0.64062	-1.28187	-4.22863	0.077549	3.496337	-2.37969
50	-0.09548	-1.19491	-0.56233	-1.05864	-3.89096	0.077343	3.321558	-2.02801
55	0.004171	-1.01049	-0.50580	-0.87480	-3.36329	0.081509	2.959056	-1.60073
60	0.086645	-0.85402	-0.46560	-0.72116	-2.98672	0.082971	2.697638	-1.28458
65	0.155764	-0.71899	-0.43793	-0.59112	-2.68316	0.082686	2.479313	-1.02919
70	0.214184	-0.6009	-0.42004	-0.48012	-2.4255	0.080898	2.285475	-0.81621
75	0.263922	-0.49637	-0.40992	-0.3847	-2.20402	0.077511	2.111216	-0.63757
80	0.306484	-0.4029	-0.40605	-0.3023	-2.00883	0.07251	1.950386	-0.48648
85	0.34303	-0.31859	-0.40723	-0.23093	-1.83538	0.06573	1.80111	-0.35911
90	0.374474	-0.24195	-0.41253	-0.16907	-1.68017	0.056974	1.662068	-0.25254
95	0.401541	-0.17183	-0.42122	-0.11548	-1.54049	0.046009	1.532381	-0.16445
100	0.424822	-0.1073	-0.43266	-0.06918	-1.41421	0.032562	1.411528	-0.09305
105	0.4448	-0.04761	-0.44637	-0.02937	-1.29973	0.016327	1.29931	-0.03687
110	0.461878	0.007837	-0.46192	0.004612	-1.19582	-0.03027	1.195818	0.005322
115	0.476391	0.059559	-0.47894	0.033329	-1.10165	-0.02582	1.101411	0.034661
120	0.488628	0.107965	-0.49712	0.057244	-1.01666	-0.05234	1.016672	0.052281
125	0.498832	0.153403	-0.51621	0.076757	-0.94057	-0.08269	0.942328	0.05948
130	0.507217	0.196169	-0.53595	0.092213	-0.87322	-0.11678	0.879098	0.057844
135	0.513966	0.236512	-0.55614	0.103911	-0.81447	-0.15414	0.827467	0.049314
140	0.519241	0.274647	-0.5766	0.112114	-0.76403	-0.19398	0.787447	0.03612
145	0.523186	0.310759	-0.59715	0.117058	-0.72131	-0.23527	0.75844	0.020562
150	0.525927	0.345008	-0.61764	0.118951	-0.68547	-0.27691	0.739282	0.004723
155	0.527578	0.377536	-0.63792	0.117984	-0.65546	-0.31795	0.728449	-0.00976
160	0.52824	0.408466	-0.65788	0.114329	-0.63021	-0.35768	0.724314	-0.02178
165	0.528005	0.437905	-0.67738	0.108146	-0.60871	-0.39566	0.725356	-0.0307
170	0.526956	0.465952	-0.69633	0.099582	-0.5901	-0.43169	0.730255	-0.03625
175	0.525169	0.492694	-0.71461	0.088776	-0.57245	-0.46636	0.737311	-0.03964
180	0.522712	0.518207	-0.73212	0.075858	-0.55775	-0.49838	0.746996	-0.03843
185	0.519648	0.542562	-0.74879	0.060954	-0.54430	-0.52849	0.757900	-0.03407
190	0.516036	0.565823	-0.76452	0.044182	-0.53173	-0.55684	0.769480	-0.02678
195	0.511929	0.588049	-0.77924	0.025656	-0.51981	-0.58354	0.781315	-0.01681
200	0.507374	0.609292	-0.79286	0.005488	-0.50834	-0.60874	0.793072	-0.00438
205	0.502418	0.629603	-0.80533	-0.01621	-0.49717	-0.63255	0.804484	0.010255
210	0.497101	0.649026	-0.81657	-0.03934	-0.48617	-0.65508	0.815343	0.026908
215	0.491463	0.667604	-0.82653	-0.06379	-0.47526	-0.67646	0.82548	0.045366
220	0.485539	0.685375	-0.83515	-0.08947	-0.46437	-0.69675	0.834758	0.065449
225	0.479362	0.702378	-0.84238	-0.11626	-0.45344	-0.71604	0.843071	0.086976
230	0.472963	0.718646	-0.84816	-0.14408	-0.44243	-0.73441	0.850329	0.109789
235	0.466369	0.734212	-0.85246	-0.17281	-0.43129	-0.75192	0.856465	0.133730
240	0.459608	0.749106	-0.85524	-0.20237	-0.42000	-0.76864	0.861425	0.158643
245	0.452703	0.763358	-0.85646	-0.23265	-0.40855	-0.78460	0.865161	0.184436
250	0.445677	0.776994	-0.85609	-0.26354	-0.39692	-0.79985	0.867644	0.210960

255	0.438550	0.790042	-0.85409	-0.29497	-0.38508	-0.81443	0.868851	0.238093
260	0.431343	0.802525	-0.85046	-0.32682	-0.37303	-0.82837	0.868768	0.265722
265	0.424072	0.814468	-0.84517	-0.35899	-0.36076	-0.84172	0.867386	0.293747
270	0.416754	0.825894	-0.83820	-0.39140	-0.34825	-0.85449	0.864702	0.322068
275	0.409404	0.836823	-0.82954	-0.42394	-0.33551	-0.86670	0.860721	0.350588
280	0.402036	0.847277	-0.81920	-0.45652	-0.32252	-0.87839	0.855449	0.37922
285	0.394663	0.857275	-0.80716	-0.48904	-0.30929	-0.88956	0.848901	0.407877
290	0.387297	0.866836	-0.79343	-0.52141	-0.29582	-0.90024	0.841090	0.436483
295	0.379948	0.875979	-0.77801	-0.55352	-0.28209	-0.91043	0.832039	0.464960
300	0.372626	0.884720	-0.76092	-0.58529	-0.26812	-0.92016	0.821768	0.493237
305	0.365339	0.893078	-0.74217	-0.61663	-0.25389	-0.92942	0.810305	0.521248
310	0.358097	0.901067	-0.72178	-0.64744	-0.23942	-0.93823	0.797677	0.548928
315	0.350906	0.908704	-0.69978	-0.67762	-0.22470	-0.94660	0.783916	0.576217
320	0.343773	0.916003	-0.67619	-0.70710	-0.20973	-0.95453	0.769060	0.603053
325	0.336703	0.922978	-0.65104	-0.73579	-0.19452	-0.96203	0.753127	0.629401
330	0.329703	0.929643	-0.62438	-0.76359	-0.17907	-0.96910	0.736165	0.655198
335	0.322777	0.936011	-0.59624	-0.79044	-0.16338	-0.97574	0.718210	0.680403
340	0.315929	0.942096	-0.56666	-0.81623	-0.14745	-0.98196	0.699302	0.704969
345	0.309162	0.947908	-0.53570	-0.84090	-0.13129	-0.98776	0.679478	0.728860
350	0.302481	0.953460	-0.50341	-0.86438	-0.11490	-0.99315	0.658780	0.752039
355	0.295887	0.958763	-0.46984	-0.88657	-0.09829	-0.99811	0.637249	0.774472
360	0.289383	0.963827	-0.43505	-0.90743	-0.08146	-1.00265	0.614926	0.796130
365	0.282971	0.968663	-0.39911	-0.92686	-0.06441	-1.00678	0.591852	0.816986
370	0.276653	0.973282	-0.36209	-0.94483	-0.04714	-1.01048	0.568078	0.837011
375	0.270430	0.977691	-0.32404	-0.96125	-0.02969	-1.01376	0.543627	0.856192
380	0.264303	0.981901	-0.28505	-0.97608	-0.01203	-1.01661	0.518557	0.874501
385	0.258272	0.985920	-0.24518	-0.98925	0.005814	-1.01904	0.492909	0.891923
390	0.252338	0.989756	-0.20453	-1.00072	0.023846	-1.02104	0.466721	0.908444
395	0.246502	0.993418	-0.16317	-1.01045	0.042060	-1.02261	0.440039	0.924051
400	0.240763	0.996913	-0.12118	-1.01839	0.060435	-1.02374	0.412894	0.938735
405	0.235121	1.000248	-0.07864	-1.02449	0.078975	-1.02444	0.385336	0.952487
410	0.229578	1.003433	-0.03566	-1.02874	0.097668	-1.02469	0.357402	0.965302
415	0.224130	1.006471	0.007689	-1.03109	0.116504	-1.02451	0.329133	0.977173
420	0.218777	1.00937	0.051315	-1.03153	0.135476	-1.02387	0.300565	0.988098
425	0.213521	1.012137	0.095124	-1.03003	0.154574	-1.02279	0.271736	0.998078
430	0.208357	1.01476	0.139021	-1.02655	0.173789	-1.02124	0.242683	1.007102
435	0.203288	1.017438	0.182922	-1.02129	0.193110	-1.01941	0.213433	1.015356
440	0.212532		0.184049		0.198314		0.226712	
445	0.232024	-1.01391	0.154529	1.028577	0.193424	1.021979	0.270307	-1.00438
450	0.251600	-1.01053	0.124927	1.033862	0.188628	1.024157	0.313617	-0.99303
455	0.271240	-1.00670	0.095267	1.038242	0.183920	1.026251	0.356541	-0.97974
460	0.290930	-1.00239	0.065582	1.041698	0.179297	1.028237	0.398981	-0.96448
465	0.310659	-0.99761	0.035902	1.04425	0.174765	1.030128	0.440849	-0.94729
470	0.330415	-0.99236	0.006252	1.045911	0.170315	1.031936	0.482048	-0.92818
475	0.350188	-0.98664	-0.02333	1.04669	0.165949	1.033661	0.522486	-0.90719
480	0.369962	-0.98045	-0.05284	1.046596	0.161665	1.035304	0.562070	-0.88434
485	0.389727	-0.97377	-0.08223	1.045644	0.157461	1.036871	0.600710	-0.85967
490	0.409469	-0.96663	-0.11150	1.043845	0.153337	1.038365	0.638319	-0.83322
495	0.429175	-0.95900	-0.14060	1.041211	0.149290	1.03979	0.674808	-0.80503
500	0.448832	-0.95091	-0.16953	1.037757	0.145320	1.041148	0.710094	-0.77515
505	0.468426	-0.94233	-0.19826	1.033496	0.141425	1.042444	0.744095	-0.74364
510	0.487945	-0.93328	-0.22677	1.028442	0.137604	1.04368	0.776730	-0.71055
515	0.507368	-0.92376	-0.25505	1.022604	0.133856	1.044859	0.807923	-0.67594
520	0.526692	-0.91377	-0.28307	1.016003	0.13018	1.045983	0.837600	-0.63988
525	0.545898	-0.90331	-0.31082	1.00865	0.126573	1.047057	0.865690	-0.60243
530	0.564973	-0.89239	-0.33829	1.000558	0.123034	1.048082	0.892123	-0.56367

535	0.583903	-0.88100	-0.36545	0.991742	0.119564	1.049061	0.916837	-0.52367
540	0.602675	-0.86915	-0.39229	0.982216	0.116160	1.049996	0.939769	-0.48251
545	0.621274	-0.85685	-0.41881	0.971993	0.112819	1.050891	0.960863	-0.44027
550	0.639687	-0.84409	-0.44498	0.961087	0.109543	1.051746	0.980066	-0.39703
555	0.657900	-0.83089	-0.47080	0.949511	0.106327	1.052566	0.997328	-0.35289
560	0.675900	-0.81725	-0.49624	0.937278	0.103170	1.05335	1.012603	-0.30793
565	0.693674	-0.80318	-0.52132	0.924400	0.100069	1.054101	1.025849	-0.26225
570	0.711208	-0.78868	-0.54600	0.910890	0.097018	1.05482	1.037027	-0.21594
575	0.728489	-0.77376	-0.57028	0.896760	0.094014	1.055507	1.046106	-0.16910
580	0.745505	-0.75842	-0.59415	0.882023	0.091050	1.056161	1.053053	-0.12183
585	0.762243	-0.74268	-0.61760	0.866690	0.088118	1.05678	1.057845	-0.07424
590	0.778690	-0.72654	-0.64063	0.850772	0.085204	1.057361	1.060459	-0.02645
595	0.794836	-0.71001	-0.66321	0.834279	0.082294	1.057895	1.060874	0.021436
600	0.810666	-0.69310	-0.68535	0.817223	0.079358	1.058366	1.059073	0.069285
605	0.826168	-0.67582	-0.70704	0.799611	0.076376	1.058761	1.055048	0.116970
610	0.841336	-0.65818	-0.72826	0.781459	0.073291	1.059042	1.04878	0.164322
615	0.856155	-0.64019	-0.74901	0.762773	0.070059	1.059171	1.040266	0.211183
620	0.870618	-0.62185	-0.76928	0.743564	0.066601	1.059085	1.029498	0.257353
625	0.884712	-0.60319	-0.78906	0.723840	0.062809	1.058685	1.016464	0.302585
630	0.898428	-0.58422	-0.80834	0.703612	0.058541	1.057836	1.001159	0.346589
635	0.911758	-0.56493	-0.82711	0.682887	0.053628	1.056356	0.983579	0.389018
640	0.924691	-0.54536	-0.84537	0.661675	0.047842	1.053988	0.963725	0.429431
645	0.937222	-0.52550	-0.86311	0.639984	0.040895	1.05038	0.941601	0.467286
650	0.949342	-0.50537	-0.88031	0.617825	0.032499	1.045119	0.917247	0.501982
655	0.961041	-0.48499	-0.89697	0.595201	0.022301	1.037665	0.890718	0.532791
660	0.972314	-0.46436	-0.91307	0.572124	0.009965	1.027409	0.862125	0.558934
665	0.983155	-0.44351	-0.92861	0.548602	0.009965	1.027409	0.840101	0.591438
670	0.993557	-0.42244	-0.94359	0.524643	0.009965	1.027409	0.810807	0.630999
675	1.003517	-0.40116	-0.95797	0.500257	0.009965	1.027409	0.779652	0.669111
680	1.013028	-0.37970	-0.97177	0.475452	0.009965	1.027409	0.746708	0.705688
685	1.022087	-0.35806	-0.98496	0.450235	0.009965	1.027409	0.712049	0.740644
690	1.030689	-0.33626	-0.99754	0.424618	0.009965	1.027409	0.675756	0.773901
695	1.038834	-0.31431	-1.00949	0.398611	0.009965	1.027409	0.637911	0.805380
700	1.046512	-0.29224	-1.02080	0.372216	0.009965	1.027409	0.598602	0.835011
705	1.053727	-0.27004	-1.03146	0.345450	0.009965	1.027409	0.557919	0.862725
710	1.060476	-0.24774	-1.04146	0.318322	0.009965	1.027409	0.515955	0.888459
715	1.066758	-0.22535	-1.05079	0.290842	0.009965	1.027409	0.472806	0.912153
720	1.072572	-0.20288	-1.05943	0.263021	0.009965	1.027409	0.428572	0.933753
725	1.077918	-0.18035	-1.06736	0.234871	0.009965	1.027409	0.383355	0.953209
730	1.082796	-0.15777	-1.07458	0.206403	0.009965	1.027409	0.337257	0.970477
735	1.087208	-0.13516	-1.08108	0.177631	0.009965	1.027409	0.290385	0.985517
740	1.091155	-0.11253	-1.08683	0.148567	0.009965	1.027409	0.242846	0.998295
745	1.094637	-0.08989	-1.09183	0.119226	0.009965	1.027409	0.194750	1.008782
750	1.09766	-0.06726	-1.09606	0.089622	0.009965	1.027409	0.146207	1.016952
755	1.100225	-0.04465	-1.09950	0.059771	0.009965	1.027409	0.097328	1.022788
760	1.102334	-0.02207	-1.10215	0.029687	0.009965	1.027409	0.048226	1.026276
765	1.103994	0.000450	-1.10399	-0.00060	0.009965	1.027409	-0.00098	1.027408

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